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E 04 H 7/04

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⑯ 軽量複合パネル築造工法

⑰ 特 願 昭56—177341

⑱ 出 願 昭56(1981)11月4日

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明 細 書

1. 発明の名称

軽量複合パネル築造工法

2. 特許請求の範囲

1. 第1鋼板と、該第1鋼板に平行すると共にその端部が第1鋼板の端部より若干外方へ突出する第2鋼板と、該両鋼板間に配設された隔板と、両鋼板間に充填された軽量気泡コンクリートとからなる軽量複合パネルの上記第2鋼板の端部を隣接する同一構造の軽量気泡パネルの第2鋼板の端部に当接させると共にその当接部を溶接し、両パネルの両第1鋼板間に鋼製蓋を配設すると共に該蓋と両第1鋼板とを溶接し、上

かも効率よくパネルを接合することができる築造工法を提供することにある、その特徴とするところは、第1鋼板と、該第1鋼板に平行すると共にその端部が第1鋼板の端部より若干外方へ突出する第2鋼板と、該両鋼板間に配設された隔板と、両鋼板間に充填された軽量気泡コンクリートとからなる軽量複合パネルの上記第2鋼板の端部を隣接する同一構造の軽量気泡パネルの第2鋼板の端部に当接させると共にその当接部を溶接し、両パネルの両第1鋼板間に鋼製蓋を配設すると共に該蓋と両第1鋼板とを溶接し、上記蓋に形成した穴を介して両パネル間に軽量気泡コンクリートを充填したことにあ

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- METHOD OF CONSTRUCTION OF LIGHT COMPOSITE PANEL

- KAWABATA UICHIROU; SHIGEFUJI MUNEYUKI; SEKINE TOSHIHIRO; ISHII MASAYUKI

- HITACHI SHIPBUILDING ENG CO

- B28B1/50; B63B5/14; B63B9/06; B63B35/44; B65D90/02; C04B21/00; E04C2/28; E04H7/04

5ついで説明す

第1鋼板(2)と、

端部が第1鋼

第2鋼板(3)と、

(4)および横隔

隔ごとに固着

れ止め部材(7)

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3. 発明の詳細な説明

本発明は、たとえば貯槽、土木建築構造物、海洋構造物等に用いる軽量複合パネルの築造工法に関し、その目的とするところは、強度が大で、し

かも効率よくパネルを接合することができる築造工法を提供することにある、その特徴とするところは、第1鋼板と、該第1鋼板に平行すると共にその端部が第1鋼板の端部より若干外方へ突出する第2鋼板と、該両鋼板間に配設された隔板と、両鋼板間に充填された軽量気泡コンクリートとからなる軽量複合パネルの上記第2鋼板の端部を隣接する同一構造の軽量気泡パネルの第2鋼板の端部に当接させると共にその当接部を溶接し、両パネルの両第1鋼板間に鋼製蓋を配設すると共に該蓋と両第1鋼板とを溶接し、上記蓋に形成した穴を介して両パネル間に軽量気泡コンクリートを充填したことにある。

以下、本発明の一実施例を図に基づいて説明する。(1)は軽量複合パネルであって、第1鋼板(2)と、該第1鋼板(2)に平行すると共にその端部が第1鋼板(2)の端部より若干外方へ突出する第2鋼板(3)と、該両鋼板(2)(3)間に配設された縦隔板(4)および横隔板(5)と、両鋼板(2)(3)の内面に適当間隔ごとに固着された縦ずれ止め部材(6)および横ずれ止め部材(7)

と、第1鋼板(2)の端部に沿って配設された縦隔板(4)上に固着されると共に第1鋼板(2)の端部に固着された縦受板(8)と、両鋼板(2)(3)間に充填された軽量気泡コンクリート(9)とからなる。02は両隔板(4)(5)に形成された連通穴、03は隣接する両パネル(1)の第2鋼板(3)の端部どうしを溶接03した状態において両パネル(1)間に配設されると共に両第2鋼板(3)および両縦隔板(4)に溶接された連結板であって、横隔板(5)と一直線状となるように構成されている。03は該各横隔板(5)上に固着された横受板、04は四辺が上記両縦受板(8)および両横受板03上に載置されると共に溶接04されて隣接するパネル(1)の両第1鋼板(2)間を塞ぐ鋼製蓋であって、この実施例では一つおきの蓋04にコンクリート打設穴04と空気抜き穴04とを形成してある。04は上記コンクリート打設穴04から両パネル(1)間に充填された軽量気泡コンクリート、0404は蓋04の内面に溶接された縦ずれ止め部材と横ずれ止め部材、04は連結板04に形成された連通穴である。

上記構成に基づいてパネル(1)の製造工法につい

て説明する。まず2つのパネル(1)の両第2鋼板(3)の端部どうしを当接させ、その当接部を溶接03する。次に連結板04を両パネル(1)間に配設すると共にこの連結板04を両第2鋼板(3)および両縦隔板(4)に溶接する。次に各連結板04上に横受板03を溶接する。次に各鋼製蓋04を受板03(8)上に載置すると共にこの各鋼製蓋04を両第1鋼板(2)に溶接04し、また隣接する蓋04どうしを溶接04する。次にコンクリート打設穴04を介して両パネル(1)間に軽量気泡コンクリート04を充填する。なおこのときコンクリート04の膨張を考慮して少なめに打設する。その後、コンクリート04が膨張充填されてコンクリート打設穴04および空気抜き穴04からあふれ出てくるのを待ち、膨張が止まった時点で、あふれ出たコンクリート04を去除けばよい。なお性能上あるいは強度上の必要がある場合には、その後、コンクリート打設穴04および空気抜き穴04に鋼製盲板を溶接するものとする。

以上述べたごとく本発明の軽量複合パネル製造工法によれば、軽量複合パネルの上記第2鋼板の

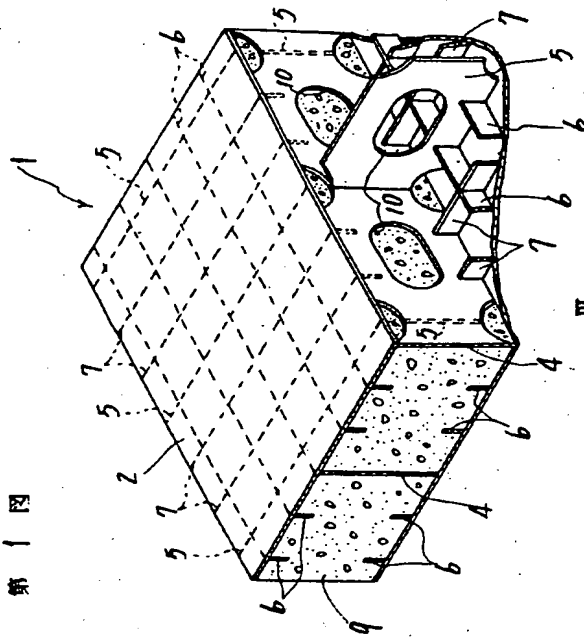
端部を隣接する同一構造の軽量気泡パネルの第2鋼板の端部に当接させると共にその当接部を溶接し、両パネルの両第1鋼板間に鋼製蓋を配設すると共に該蓋と両第1鋼板とを溶接し、上記蓋に形成した穴を介して両パネル間に軽量気泡コンクリートを充填するものであって、効率よくパネルを接合することができ、しかもその強度を大にすることができるものである。したがって貯槽、土木建築構造物、海洋構造物等を構成するのに最適である。

#### 4. 図面の簡単な説明

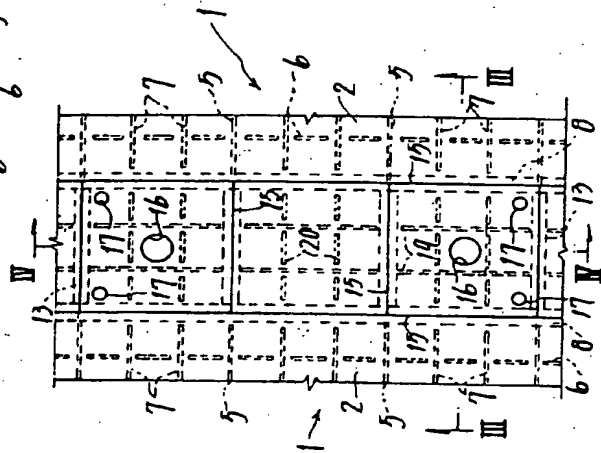
図は本発明の一実施例を示し、第1図は軽量複合パネルの一部切欠き斜視図、第2図は接合部の平面図、第3図は第2図のⅡ-Ⅱ矢視図、第4図は第2図のⅠ-Ⅰ矢視図である。

(1)…軽量複合パネル (2)…第1鋼板 (3)…第2鋼板 (4)…縦隔板 (5)…横隔板 (9)…軽量気泡コンクリート 02…溶接 04…鋼製蓋 0404…コンクリート打設穴 04…軽量気泡コンクリート

代理人 森 本 義 弘

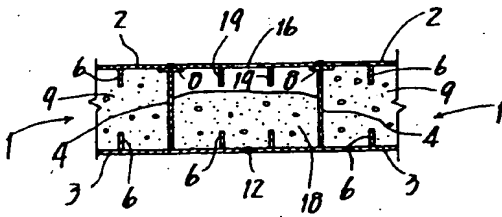


第 1 図

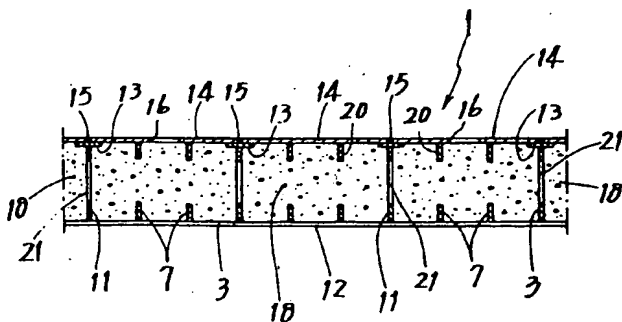


第 2 図

第 3 図



第 4 図



第 1 頁の続き

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号日立造船株式会社内

## SPECIFICATION

## 1. Title of the Invention:

CONSTRUCTION METHOD FOR LIGHTWEIGHT COMPOSITE PANEL

## 2. Claims

1. A construction method of a lightweight composite panel, characterized in that an end of a lightweight composite panel comprising a first steel plate, a second steel plate that is parallel to the first steel plate and that protrudes outwardly further than an end of the first steel plate, and lightweight cellular concrete filled between the steel plates is brought into contact with an end of a second steel plate of an adjacent lightweight composite panel having the same structure thereas; contact portions thereof are welded; steel covers are disposed between the two first steel plates of the two panels; the covers and the two first steel plates are welded together; and lightweight cellular concrete is filled between the two panels through openings formed in the covers.

## 3. Detailed Description of the Invention

The present invention relates to a construction method for a lightweight composite panel for use with, for example, a storage tank, a civil work construction structure, and a marine structure, and an object thereof is

to provide a construction method capable of connecting panels with high strength and high efficiency. The construction method is characterized in that an end of a lightweight composite panel comprising a first steel plate, a second steel plate that is parallel to the first steel plate and that extends outwardly further than an end of the first steel plate, and lightweight cellular concrete filled between the steel plates is brought in contact with an end of a second steel plate of an adjacent lightweight composite panel having the same structure thereas; contact portions thereof are welded; steel covers are disposed between the two first steel plates of the two panels; the covers and the two first steel plates are welded together; and lightweight cellular concrete is filled between the two panels through openings formed in the covers.

Hereinbelow, an embodiment of the present invention will be described with reference to drawings. Numeral (1) denotes a lightweight composite panel including a first steel plate (2); a second steel plate (3) that is parallel to the first steel plate (2) and that protrudes outwardly slightly further than an end of the first steel plate (2); vertical partition plates (4) and transverse partition plates (5) that are provided between the steel plates (2) and (3); vertical anchor members (6) and transverse anchor members (7) that are fixed to inner surfaces of the steel

plates (2) and (3) at appropriate spaced intervals; vertical backing plates (8) that are fixed onto the vertical partition plates (4) disposed along the end of the first steel plate (2) and that are fixed to the end of the first steel plate (2); and lightweight cellular concrete (9) filled between the steel plates (2) and (3). Numeral (10) denotes communication holes formed in the two partition plates (4) and (5); (11) denotes connecting plates that are disposed between the two panels (1) in a state the ends of the second steel plates (3) of the mutually adjacent two panels (1) are welded (12) together, that are welded to the two second steel plates (3) and the two vertical partition plates (4), and that are formed to become the straight line with the transverse partition plates (5). Numeral (13) denotes transverse backing plates fixed on the transverse partition plates (5); and (14) denotes steel covers that have four sides placed over the two vertical backing plates (8) and the two transverse backing plates (13) and that are connected via welds (15) to thereby steel cover between the two first steel plates (2) of the adjacent lightweight composite panels (1), wherein, in the present embodiment, concrete filling openings (16) and air vent openings (17) are formed in the every other cover (14). Numeral (18) denotes lightweight cellular concrete filled between the two panels (1) from

the concrete filling openings (16); (19) and (20) denote, respectively, vertical anchor members and transverse anchor members welded to inner surfaces of the covers (14); and (21) communication holes formed in the connecting plates (11).

With reference to the above construction, the construction method will be described. First, the ends of the two second steel plates (3) of the two lightweight composite panels (1) are brought into contact with each other, and contact portions thereof are connected via a weld (12). Then, the connecting plates (11) are disposed between the two panels (1), and are welded to the two second steel plates (3) and the two vertical partition plates (4). Next, the transverse backing plates (13) are welded onto the individual connecting plates (11). Then, the individual covers (14) are placed over the backing plates (13) and (8), and the covers (14) are connected via the welds (15) to the two first steel plates (2), and the adjacent covers (14) are connected together via the welds (15). Subsequently, the lightweight cellular concrete (18) is filled between the two panels (1) through the concrete filling openings (16). At this time, the concrete is poured slightly small in amount in consideration expansion of the lightweight cellular concrete (18). Thereafter, waiting for the expansion-filled lightweight cellular



concrete (18) overflowing from the concrete filling openings (16) and the air vent openings (17), the overflowed lightweight cellular concrete (18) is removed when the expansion stops. Thereafter, when needs exist for performance and strength, steel blind plates are welded to the concrete filling openings (16) and the air vent openings (17).

As described above, in the construction method of a lightweight composite panel according to the present invention, the end of the second steel plate of the lightweight composite panel is brought into contact with the end of second steel plate of the adjacent lightweight composite panel having the same structure thereas; the contact portions thereof are welded; the steel covers are disposed between the two first steel plates of the two panels; the covers and the two first steel plates are welded together; and the lightweight cellular concrete is filled between the two panels through the openings formed in the covers, whereby the panels can be connected efficiently and the strength thereof can be increased. Accordingly, the construction method is most suitable to construct a storage tank, a civil work construction structure, a marine structure, or the like.

#### 4. Brief Description of the Drawings

Drawings show an embodiment of the present invention,

wherein Fig. 1 is a partially cutout perspective view of a lightweight composite panel, Fig. 2 is a plan view of connected portions, Fig. 3 is a sectional view taken along the line III-III of Fig. 2, and Fig. 4 is a sectional view taken along the line IV-IV of Fig. 2.

(1): lightweight composite panel; (2): first steel plate; (3): second steel plate; (4): vertical partition plate; (5) transverse partition plate; (9) lightweight cellular concrete; (12) weld; (14): steel cover; (16): concrete filling opening; (18): lightweight cellular concrete

## SPECIFICATION

### 1. Title of the Invention:

CONCRETE COMPOSITE PANEL AND MANUFACTURING METHOD THEREFOR

### 2. Claims

1. A concrete composite panel characterized by comprising a columnar steel fiber concrete layer and an ordinary concrete layer therearound between a pair of opposing steel plates.

2. A manufacturing method for a concrete composite panel, characterized in that a partition cylinder is disposed between a pair of opposing steel plates, wherein steel fiber concrete is poured into the partition cylinder, ordinary concrete is poured between the partition cylinder and the steel plates, and the partition cylinder is then pulled out.

### 3. Detailed Description of the Invention

The present invention relates to a concrete composite panel and a manufacturing method therefor, and an object thereof is to propose a concrete composite panel having a large load bearing capacity and high deformability, and to an effective manufacturing method therefor.

As shown in Fig. 1, a concrete composite panel includes a plurality of girder webs (2) between a pair of mutually opposing steel plates (1) and a concrete layer (4)

anchored by anchor members (3) is sandwiched between the pair of steel plates (1). In the known composite panel, the concrete layer (4) is composed of an ordinary concrete, that is, concrete that has a sufficient strength and that is mixed with gravel (or aggregate) having an appropriate fineness modulus. Structural features of the composite panel include:

(1) Since the panel has a relatively high dead weight, when it is used as a structural material of a large marine structure, it is capable of exhibiting ballast effects for offsetting buoyancy.

(2) The panel has a high deformability and hence maintains a large amount of absorbed energy until it breaks down.

(3) Since the steel plates are disposed on the outer surfaces, even when cracking has occurred in the internal concrete layer, it does not diminish waterproofing property.

(4) Since block-jointing construction primarily uses a welding process, the panel results in exhibiting high reliability.

To investigate the strength properties of the composite panel, the present inventors prepared a girder model having a unitary width and performed load testing.

Fig. 2 shows a case where a girder model (5) receives a combined load of a bending load and a shear load. An arrow (7) indicates a load direction. A crack occurrence

state in this case is shown in Fig. 4. As are apparently shown in Fig. 4, cracks (X) occurred from the anchor member positions of a concrete layer (8), wherein arches are individually formed as cracks each develop in an oblique direction at  $45^\circ$ , and the loads are thus born. When the load further increased, breakdown occurred at a buckling of a compression-side steel plate (9A) following breakdown in partial regions (10) of a concrete layer (8) and breakage of a tension-side steel plate (9B). From the above, it can be known that in a sandwich-type composite structure, high loads are finally born according to arch effects, and the deformability can be increased by large deformation of the tension-side steel plate.

Fig. 3 shows a case where a girder model (11) primarily receives a shear load. An arrow (13) indicates a load direction. A crack occurrence state in this case is shown in Fig. 5. With the load being exerted, cracks (Y) occurred from the vicinities of the positions of the anchor members, and the cracks individually develop in an oblique direction at  $45^\circ$ . Thereby, arches are formed in the girder model (11), and the load is born until a high load is reached. When the load further increases, abrupt cracks (Z) occurred in a concrete layer (14) because of oblique tension attributed to shearing. Resultantly, the concrete layer (14) was crushed, and the girder model (11) collapsed.

However, the deformability before the collapse occurs is sufficiently high, and the amount of absorbed energy is large.

The concrete layers (8) and (14) of the girder models (5) and (11) described using Fig. 2 to Fig. 5 are individually formed of ordinary concrete described above. The breakdown state of the girder model in which mortar (concrete without gravel) or low-strength concrete was used instead of the ordinary concrete was as described hereunder. When a load was exerted, cracks corresponding to the cracks (Y) occurred. Cracks corresponding to the cracks (Z) occurred with a low load being exerted, the girder model abruptly broke down. That is, the girder model broke down with oblique tension without forming an arch. Moreover, substantially no deformability was observed, and the concrete layer did not crush.

The crack occurrence states are considered different from each other for reasons as described hereunder.

(1) As shown in Fig. 6, in a case where concrete (15) appropriately contains aggregate (or, gravel) (16), specifically, in a case where the fineness modulus is high, even when cracks corresponding to the cracks (Y) occurred, engagement effects of inter-aggregate (16) pieces took place in a crack face (17). In this case, a certain amount of shear force propagates even on the crack face (17).

(2) As shown in Fig. 7, while oblique tension can cause a preliminary microcrack ( $Z_1$ ) corresponding to the crack (Z), the aggregate (16) pieces work as crack arresters, hindering growth or development of the crack.

(3) Even with concrete containing the aggregate (16), when the strength thereof is low, also the tensile strength and the adhesion between the aggregate (16) pieces and cement are low, as a matter of course. Accordingly, the effects described in (1) and (2) are reduced.

The final breakdown of the girder model receiving the shear load is caused by the cracks (Z), that is, the oblique tension cracks. As such, it is considered that since the concrete improves in tensile strength with steel fiber being mixed thereinto, thereby enabling the shear strength to increase for resisting oblique tension cracks. In practice, the tensile strength of concrete can be 40-50% improved by the steel fiber.

Fig. 8 shows load vs. displacement relationships in a case where the steel fiber is mixed and a case where the steel fiber is not mixed. In the figure, a solid line (a) indicates the characteristics of ordinary concrete, and a dotted line (b) indicates the characteristics of steel fiber concrete. In addition, ( $P_1$ ) and ( $P_2$ ) individually indicate collapsing points of the cases. It can be known from this figure that when the steel fiber of 1.5% by

volume is mixed into the concrete, the final strength of the concrete is increased by 22%, and the rigidity thereof becomes twice as high. As such, while the steel fiber concrete can be said to be a very superior structural material, the deformability thereof is reduced by approximately 20% compared to the ordinary concrete. As a result of the experiment, in the girder model using the steel fiber concrete, while cracks corresponding to the cracks (Y) occurred, the widths of the cracks were small. However, cracks corresponding to the cracks (Z) abruptly occurred, resulting in collapse of the girder model. In addition, the elongation of the tension-side steel plate is low, therefore substantially not causing displacement. Reasons therefor are considered as described hereunder.

(1) While the steel fiber much works to increase the tensile strength of the concrete, the ratio between the steel material and the concrete is increased, thereby restraining cracks corresponding to the cracks (Y). Accordingly, the above avoids energy absorption attributed to aggregate engagement in the position of the cracks (Y).

(2) Since the cracks corresponding to the cracks (Y) are restrained, elongate deformation of the tension-side steel is restrained.

(3) Since cracks corresponding to the cracks (Y) do not sufficiently develop, no arch is formed. As such,



significant shear deformations, that is, oblique tensions, occur in the concrete.

It can be known from the above that the matters described hereinbelow should be taken into consideration when building a structure superior in load bearing capacity and deformability.

(1) To render the concrete to resist a high load, an arch should be formed, and the tension strength of the arch should be increased (in order to resist oblique tension cracks).

(2) To increase the deformability, the concrete needs to be rendered to cause cracks corresponding to the cracks (Y).

(3) The aggregate engagement effects of the face of the crack corresponding to the crack (Y) are effective for energy absorption; therefore, the effects should be taken into consideration.

The present invention is made taking the aspects described in (1) to (3) into consideration, and an embodiment thereof will be described hereinbelow with reference to Fig. 9 to Fig. 11.

Fig. 9 shows a concrete composite panel. Symbols (20A) and (20B) denote steel plates containing respective anchor members (20a) and (20b). A plurality of girder webs (21) are provided with predetermined spaced intervals

between the pair of steel plates (20A) and (20B), and the concrete layers (22) are formed in units of a portion surrounded by the pair of steel plates (20A) and (20B) and the pair of mutually adjacent girder webs (21) and (21). The pair of steel plates 20A and 20B are thus disposed such that the obverse and reverse surfaces thereof are mutually opposite via the concrete layer (22) being sandwiched thereby. The concrete layer (22) is formed to include an ordinary concrete layer (23A) and a steel fiber concrete layer (23B). The steel fiber concrete layer (23B) is formed columnar in a central portion of the portion surrounded by the pair of steel plates (20A) and (20B) and the pair of girder webs (21) and (21); and the ordinary concrete layer (23A) is formed of peripheral portions thereof. In the concrete composite panel, the concrete layer (22) is anchored by the anchor members (20a) and (20b). In addition, steel fiber concrete having a tensile strength two times higher than that of the ordinary concrete is disposed in critical portions wherein oblique tension cracks are predicted to occur when positive/negative loads are exerted. As such, oblique tension cracks are hindered to occur, and a high load can be born. Since the steel fiber concrete of 1.5% by volume does not have a compressive strength beyond 1.2 times higher compared to the ordinary concrete, the layer (23B)

need not be extended to the compressive region. For example, with positive/negative loads being exerted, two types of cracks ( $C_1$ ) and ( $C_2$ ) occur in the concrete layer (22), as shown in Fig. 11. However, the two types of cracks ( $C_1$ ) and ( $C_2$ ) do not provide influences when the individual loads are exerted. Specifically, while the crack ( $C_1$ ) is occurring, the crack ( $C_2$ ) is closed to form a compressive region arch. An oblique tension cracks is hindered by the steel fiber concrete (28B) not to occur or is restrained thereby. Consequently, the concrete composite panel described above does not cause abrupt breakdown and has high deformability.

A manufacturing method will now be described hereinbelow. As shown in Fig. 10, the plurality of girder webs (21) are disposed between the pair of steel plates (20A) and (20B) (for example, they are fixed by welding to the steel plates (20A) and (20B)) with predetermined spaced intervals. A form thus built is disposed so that a spacing (24) surrounded by the pair of steel plates (20A) and (20B) and the pair of mutually adjacent girder webs (21) and (21) is formed to be vertically long. Then, a partition cylinder (25) (a steel pipe, for example) is inserted in the spacing (24) to be positioned in a central portion thereof. In this state, steel fiber concrete is poured into the partition cylinder (25). Additionally, ordinary

concrete is poured into peripheral portions of the partition cylinder (25). The pouring sequence may be optionally determined. Before the concrete hardens, the partition cylinder (25) is pulled out, and border faces are mutually engaged by using a vibrator or the like onto outer surfaces of the steel plates (20A) and (20B).

As is apparent from the above description, the present invention enables the concrete composite panel superior in load bearing capacity and deformability to easily be provided.

#### 4. Brief Description of the Drawings

Fig. 1 is a sectional perspective view of a conventional example; Fig. 2 and Fig. 3 are girder-model perspective views; Fig. 4 and Fig. 5 are explanatory views of crack occurrence states; Fig. 6 and Fig. 7 are explanatory views of engagement effects; Fig. 8 is a view showing a load vs. displacement relationship; and Fig. 9 to Fig. 11 shows an embodiment of the present invention, Fig. 9 being a sectional perspective view, Fig. 10 being an explanatory view of a manufacturing method, and Fig. 11 being an explanatory view of a crack occurrence state.

(20A), (20B): steel plate; (20a), (20b): anchor member; (21): girder web; (22): concrete layer; (23): steel fiber concrete layer; (23A), (23B): ordinary concrete layer; (24A), (24B): border face; (25) partition cylinder;

(26): partition plate; (27): closing plate